

ESCI 503 – The Cryosphere Spring 2018

Instructors: Dr. Lauren Simkins (lsimkins@rice.edu), Dr. John Anderson (johna@rice.edu)

Instructor office / hours: LS - 209 Keith-Wiess / Wednesday 1:30-3:00
JA - 210 Keith-Weiss / Tuesday & Thursday 1:00-2:30

Lecture sections: Tuesday & Thursday 2:30-3:45 in KWGL 128

Course website: The course website on OWL Space will be updated regularly throughout the term with lectures, assignments, and grades. You will submit assignments via the website.

Special Accommodations: Any student with a disability that requires special accommodations for this course is encouraged to contact the instructor. Students should also contact Disability Support Services in the Allen Center.

Required textbook: No textbook is required for the course; however, I recommend the following textbooks if you feel the need to supplement the lectures or want more information about a specific subject:

Antarctic Marine Geology, J. B. Anderson, 1999. ISBN - 9780521131681

Glaciers and Glaciation, D. Benn and D. J. A. Evans, 2010. ISBN – 9780340905791.

Earth's Climate: Past and Future, W. F. Ruddiman, 2001. ISBN - 9780716737414.

Course description: The growth and decay of glaciers play a large role in modulating Earth's climate system. This course focuses on physical glaciology, glacial geomorphology, the geologic record of glaciation, and glacier-climate interactions in the past, present, and future.

Learning objectives

Active participation on your part is necessary to develop an environment of exchange and inquiry.

Throughout the semester, you will be challenged to:

- Understand factors and feedbacks that control the cryosphere
- Explain the geologic record of glaciation throughout Earth's history
- Discuss the relationship between glaciers and climate in the past, present, and future
- Demonstrate skills in critical thinking, basic mathematics (algebraic equations and interpreting statistical results), and assess and communicate observations and interpretations

Grades

Reading assignments (20%)

Paper (20%)

Presentations (12.5% each, total 25%)

Exams 1 & 2 (15 & 20 %, respectively)

Reading assignments and presentation: You will have the opportunity to read and summarize 8 peer-reviewed articles. These reading assignments are designed to complement lectures and facilitate fruitful discussion. Electronic versions of your summaries (< 1 page) are due each Wednesday by midnight, submitted on OWL Space. On Thursdays, one student will lead ~15-minute discussions on the topic of the assigned article. These presentations will provide a more comprehensive background of the topic by, for example, discussing the motivation, problems, methods, alternative views, significance, and ideas for further questions to explore. These are not formal presentations and will be punctuated with active discussion.

Paper and presentation: Each student will choose a topic to independently explore. The paper (≤ 5 pages) will be completed in segments over the semester that will follow the structure of a short review paper. The first step after identifying the topic will be to gather 3-5 key peer-reviewed articles that will help you understand the topic. The next steps will involve writing an introduction outlining the topic, problems, and motivation, followed by the body of the paper where you will explore the topic (and relevant methods) in detail based on the literature. Once you submit the completed paper, you can re-submit for a potentially improved grade. On the last two days of class, students will give a short 10-minute presentation on their paper topics.

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Exams: The two exams will be comprehensive; therefore, material from exam 1 will be included in exam 2. The exams will primarily be short answer and essay.

Honor code: All graded materials are to be completed following the Rice Honor Code. Guidance on the Honor Code can be found at (<http://honor.rice.edu/academic-resources>). Examinations are to be completed without the guidance of anyone else and external resources. Reading assignments and presentations must reference citations where needed and be in your own words (i.e. no quotations and no copying text).

Tentative course schedule

Week	Dates	Tuesday	Thursday
1	1/9 & 1/11	What is the cryosphere?	Glacier basics: Part I
2	1/16 & 1/18	Glacier basics: Part II	Glacier flow & ice-bed interactions <i>Discussion of Winsborrow et al. 2016*</i>
3	1/23 & 1/25	Glacial hydrology <i>Submit paper topic*</i>	Ice sheets & their margins <i>Discussion of Rignot et al. 2011*</i>
4	1/30 & 2/1	Historical and satellite era observations	Ice cores <i>Discussion of Velicogna 2009*</i>
5	2/6 & 2/8	Terrestrial records <i>Submit paper literature list*</i>	Spring recess – No class
6	2/13 & 2/15	Marine records: Part I (JA)	Marine records: Part II (JA) <i>Discussion of Simkins et al. 2017*</i>
7	2/20 & 2/22	Earth's glacial history (JA)	Midterm Exam
8	3/1 & 3/3	Spring break – No class	Spring break – No class
9	3/8 & 3/10	Pliocene through Late Quaternary glaciations (JA) <i>Submit paper outline*</i>	Last Glacial Maximum to Present: Northern Hemisphere <i>Discussion of Carlson et al. 2008*</i>
10	3/15 & 3/17	Last Glacial Maximum to Present: Antarctica Ice Sheet (JA)	Sea level; Part I (JA) <i>Discussion of Dutton et al. (2015)*</i>
11	3/22 & 3/24	Sea level: Part II <i>Submit paper introduction*</i>	Ice sheet models <i>Discussion of Robel 2017*</i>
12	3/29 & 3/31	Ice shelves & sea ice	Midterm recess – No class
13	4/5 & 4/7	Permafrost & methane	Virtual field trip to Washington State (JA)
14	4/12 & 4/14	Societal impacts of cryosphere change <i>Submit completed paper*</i>	Future predictions <i>Discussion of Meier et al. 2007*</i>
15	4/19 & 4/21	Student presentations	Student presentations
Take-home final exam (pick up April 25-27, due May 2 at 5 pm in Dr. Simkins' mailbox in the main office, revised papers also due at this time)			

* Due Tuesday at midnight, submitted on OwlSpace

* Summaries due Wednesday at midnight, submitted on OwlSpace

Paper list

- Carlson, A. E., LeGrande, A. N., Oppo, D. W., Came, R. E., Schmidt, G. A., Anslow, F. S., ... & Obbink, E. A. (2008). Rapid early Holocene deglaciation of the Laurentide ice sheet. *Nature Geoscience*, 1(9), 620-624.
- Dutton, A., Carlson, A. E., Long, A. J., Milne, G. A., Clark, P. U., DeConto, R., ... & Raymo, M. E. (2015). Sea-level rise due to polar ice-sheet mass loss during past warm periods. *science*, 349(6244), aaa4019.

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- Meier, M. F., Dyurgerov, M. B., Rick, U. K., O'neel, S., Pfeffer, W. T., Anderson, R. S., ... & Glazovsky, A. F. (2007). Glaciers dominate eustatic sea-level rise in the 21st century. *Science*, 317(5841), 1064-1067.
- Rignot, E., Mouginot, J., & Scheuchl, B. (2011). Ice flow of the Antarctic ice sheet. *Science*, 333(6048), 1427-1430.
- Robel, A. A. (2017). Thinning sea ice weakens buttressing force of iceberg mélange and promotes calving. *Nature Communications*, 8.
- Simkins, L. M., Anderson, J. B., Greenwood, S. L., Gonnermann, H. M., Prothro, L. O., Halberstadt, A. R. W., ... & DeConto, R. M. (2017). Anatomy of a meltwater drainage system beneath the ancestral East Antarctic ice sheet. *Nature Geoscience*, 10(9), 691-697.
- Velicogna, I. (2009). Increasing rates of ice mass loss from the Greenland and Antarctic ice sheets revealed by GRACE. *Geophysical Research Letters*, 36(19).
- Winsborrow, M., Andreassen, K., Hubbard, A., Plaza-Faverola, A., Gudlaugsson, E., & Patton, H. (2016). Regulation of ice stream flow through subglacial formation of gas hydrates. *Nature Geoscience*, 9(5), 370-374.